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NOTES ON THE INTERACTION OF THE SKIPPER BUTTERFLY *CALPODES ETHLIUS* (LEPIDOPTERA: HESPERIIDAE) WITH ITS LARVAL HOST PLANT *CANNA EDULIS* (CANNACEAE) IN MAZATLAN, STATE OF SINALOA, MEXICO

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Abstract.—The hesperiid butterfly *Calpodes ethlius* is very widely distributed in the subtropical and tropical regions of North, Central, and South America, where the larval stage is a specialized herbivore of various Cannaceae, mostly *Canna*. The larvae are known to be occasional defoliators of cannas, including ornamental species. Some quantitative aspects of the interaction between *C. ethlius* and several patches of an ornamental species *Canna edulis*, were examined at Mazatlan, State of Sinaloa, Mexico, at the beginning of the dry season. Defoliation from *C. ethlius* was very severe during the previous wet season as indicated by aging conspicuous leaf damage to most plants in all patches, lack of new vegetative growth, and an abundance of old fecal pellets from larvae. Only a few late instar larvae and adults were present at this time. A large number of pupae were found in the host plant patches but more than 90% were parasitized, apparently by a chalcid wasp. Although *C. edulis* blooms profusely here in the early dry season, very few flowers and fruits were present. Presumably the larval population of *C. ethlius* peaks during the latter half of the wet season following a period of steady increase in response to an abundant food supply. The dry season interrupts this trend in abundance and the population drops off. Severe attack by chalcid parasites in the late wet season intensifies this change in population structure. The parasites cause mortality in the pupal stage thus precluding any regulatory effects on the larval population. Such interactions lower the ability of the infested larvae to produce flowers and fruit. Other aspects of these interactions are discussed.

Calpodes ethlius Stoll (Hesperiidae) is a well known medium-sized brown skipper butterfly with an extensive geographical range comprising predominantly southern North America, Central America, and much of South America (Klots 1951: MacNeill in Howe 1975). Several early studies re-

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vealed a life history pattern for *C. ethlius* in which the larvae feed on cannas (*Canna* spp., Cannaceae—see Tietz 1972). Although the Cannaceae is a tropical and subtropical family, native to the West Indies and Central America (Heywood 1978), the widespread popularity of cannas as ornamentals has been a probably significant ecological factor in accounting for the extensive range of this butterfly (MacNeill in Howe 1975). Although the life cycle and association of *C. ethlius* larvae with cannas has been examined (e.g. Cockerell 1892; Scudder 1889; Seitz 1924; Klots 1951, and several other references) and it has been noted that the larvae are sometimes severe defoliators (Klots 1951), there are no published studies on the quantitative aspects of the butterfly's interaction with the host plant. The purpose of the present paper is to report one short-term study on the abundance of larvae and pupae of *C. ethlius* in different patches of *Canna edulis* in Mazatlan, State of Sinaloa, Mexico at the beginning of the dry season, and to make a preliminary assessment of the possible ecological impact of the butterfly on the host plant. This is not an attempt to establish broad generalizations about the population biology of this obviously very successful species, as to do so would require long-term studies in many regions.

Locality and Methods

The distribution and abundance of larvae and pupae, along with notes on adults, of *C. ethlius* were studied in Mazatlan (18°02′N; 96°54′W), State of Sinaloa, along the Pacific Coast of Mexico, 12–14 November 1979. This region is best described as coastal tropical dry forest, with mostly open and scattered scrub forest (Fig. 1) save for large tracts of experimental agricultural lands for *Citrus* and other crops. A strong and long dry season occurs here each year, usually from the end of October through June. A large portion of the natural plant communities of the region go deciduous during the dry season.

Within the last seven years, Mazatlan experienced a large expansion of the tourist industry, resulting in the construction of several major hotels with extensive gardens and recreational grounds containing numerous ornamental plants, including numerous patches of *Canna* plants (Fig. 2). Discussions with three local gardeners employed by hotels revealed that the patches of *Canna* were generally less than six years old. In the central (old) section of the city, however, *Canna* has been present in scattered small patches in homes. At the time of this study there was a total of eight patches of *Canna* associated with two hotels and one small shopping center in the tourist area. Other patches of *Canna* were undoubtedly present at other hotels but these were not examined.

I counted the number of *C. ethlius* larvae and pupae (including empty and parasitized pupae [Fig. 3]) in eight different patches of *Canna*. This was

Fig. 1. The open scrub forest habitat characteristic of the Mazatlan region.

done by carefully examining each plant within a patch, unfolding rolled leaves and opening the characteristic tent-like structures made by the larvae. The relatively large final instar larva (60–65 mm) and pupa (38–42 mm) make it easy to locate *C. ethlius* on its host plants. The size distribution of larvae was noted. With the exception of four larvae taken for rearing to confirm species, the larvae and living pupae were left undisturbed following the census. Samples of obviously parasitized (dead) pupae were also taken. The number of plants in each patch was recorded, along with the heights of the plants and numbers of flowers and fruits. An estimate of defoliation activity by *C. ethlius* was obtained by counting the numbers of leaves with at least 20% surface area missing and bearing the easily-recognized defoliation pattern of the larger larvae of this species. The ground beneath each patch was also examined for the presence of fresh and old feces of the larvae. The incidence of successfully-eclosed *C. ethlius* in each patch was estimated by counting the number of empty pupal cases (Fig. 3). The pupae and pupal cases of *C. ethlius* can generally be counted accurately as they are usually protected within the individual tent-like structures made by the larvae prior

Fig. 2. (A) Typical hotel garden environment in the tourist area of Mazatlan where patches of *Canna edulis* (Cannaceae) are grown as ornamentals. (B) Typical patterns of leaf destruction from larvae of *Calpodes ethlius* on its host plant, *Canna edulis*; usually only 1–2 per leaf.

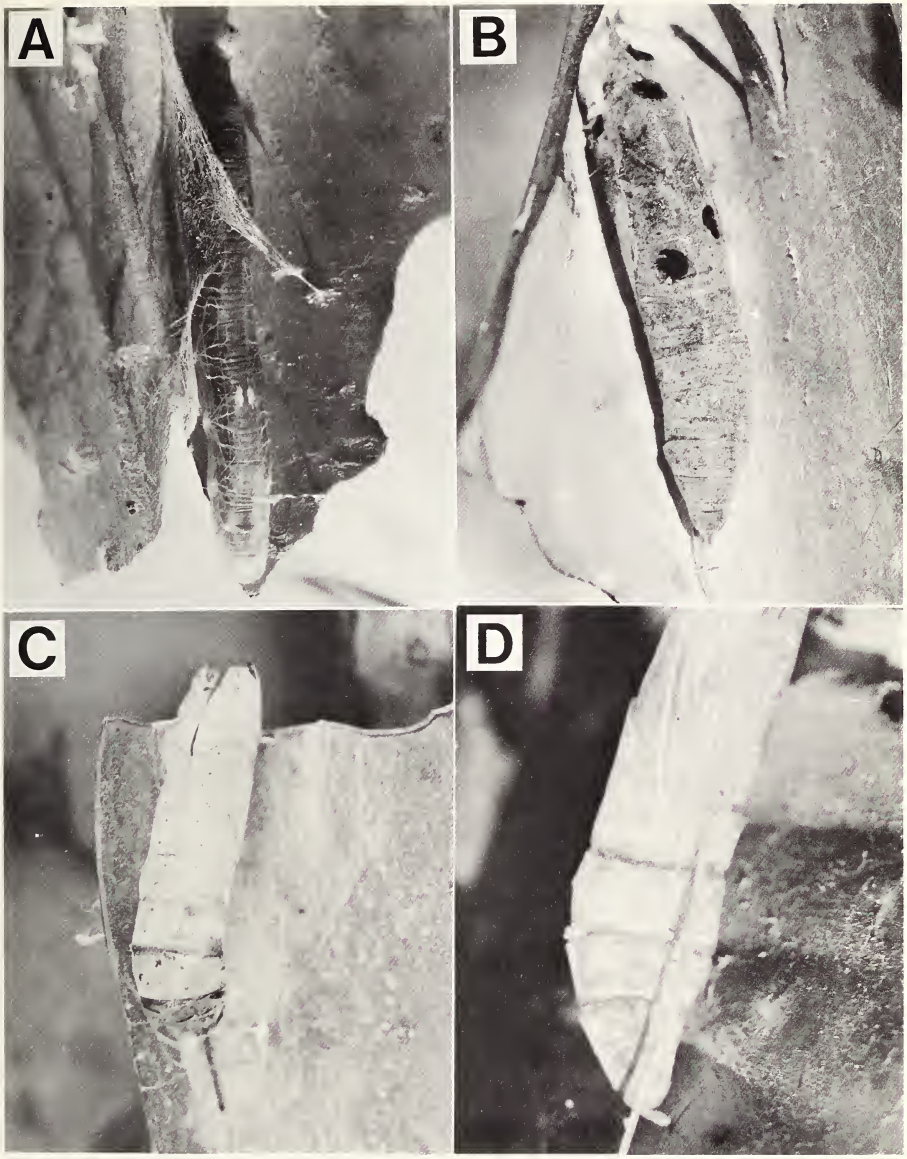


Fig. 3. (A) Final instar larvae of *C. ethlius*. Note internal structures visible through thin cuticle and the silk netting lining the opened tent-like structure. (B) Parasitized pupa of *C. ethlius* showing exit holes of apparently chalcid wasps. (C–D) Intact pupal shells following adult eclosion; note the long proboscis case (D) characteristic of *Calpodes*. Healthy, parasitized, and empty pupal shells are found inside the tent-like structures built by the larvae.

to pupation. Most or all individuals pupate on the host plant, or within a patch of the host plant. The host plant patches selected for study were widely distributed with most inter-patch distances being greater than 30 meters, but with the closest distance between one particular pair being 500 meters, and between another pair, only one meter. Records were kept on the coniditions of plants in these patches to determine whether or not there was a pattern of plant healthiness with the abundance of *C. ethlius*. Other ornamentals were examined briefly to check for signs of defoliation. A sample of healthy larvae was brought to Milwaukee for completion of the life cycle. Various patches of flowers in the many surrounding gardens were examined for adult *C. ethlius*, as this particular skipper is well known to visit flowers (Klots 1951). Searches for adults were also made at the larval host plant patches.

Results

The sizes of the eight *Canna* patches studied as host plant resources for *C. ethlius* ranged from 10 to 150 mature plants. These patches (Figs. 4–6) showed varying but noticeable levels of defoliation by larval *C. ethlius* (Fig. 7) with the percentage of defoliated plants (Fig. 4) ranging from 90–100%. The percentages of defoliated leaves (Fig. 7) in patches ranged from 80–95%. The herbivore damage on most plants in all of the patches was not fresh. The damaged leaf edges were generally brown and dry. When cut with a knife, leaf edges of *Canna* do not become brown for at least three days and probably considerably longer. A large patch of about 100 plants contained about 500 leaves whereas small patches, those with 10–15 plants, contained about 100 leaves. Height range was very similar for all eight patches, being 0.75 to 1.5 meters. The abundance of flowers (Fig. 7) was very low: there were 0–3 flowers among the different patches. Fruits were absent from three of the patches with the following distributions among the patches: 26 fruits on 13 stalks, 22 fruits on 9 stalks, 8 fruits on 4 stalks. Of the total of 56 fruits present, 50 were brown and partly dehisced with the hard black seeds exposed; the remaining few were green. Fruits (Fig. 6) were scarce relative to the numbers of plants in the patches. Only close to full-grown larvae and empty pupal shells were present at this time (Fig. 3). A total of 11 larvae were found, with none found in four of the patches. One patch of about 100 plants had more than 1,000 old fecal pellets beneath them, while another patch of only 48 plants also had more than 1,000 pellets. Of 135 pupae found, 132 or 97% were parasitized, all by the same species of an undetermined chalcid wasp. The parasite exit holes were the same (Fig. 3) in all of these pupae, suggesting a single species of parasite. Only two eclosed pupae were found, and one living pupa. No other insects were found feeding on the cannas at this time. A total of four adult *C. ethlius*

Fig. 4. One of the patches of *Canna edulis* examined for defoliation by *Calpodes ethlius* in Mazatlan. This patch contains 97 plants; note flower stalks above the leaf canopy.

were seen at two different flower patches on a single morning during a two-hour observation period split between the patches. The adults exhibited considerable home-range movements at the flower patches, darting off from perches on leaves (Fig. 8) only to return a short time later. One other skipper, *Quinta cannae* (Herrich-Schaffer), presumably another *Canna*-feeder, was seen at the flower patches. Larvae or pupae of *Q. cannae* were not found in the patches studied.

The larva of *C. ethlius* builds at tent-like structure (Fig. 7) folding over the edge of a leaf and anchoring it in place with two widely-spaced multi-stranded bands of silk. Owing to a very thin cuticle (Fig. 3) it is probably very vulnerable to desiccation, especially in dry areas such as Mazatlan. Larvae feed primarily after dusk and on the same leaves where their tents are located (Fig. 7). In the laboratory in Milwaukee, the pupa stage lasted 11 days, with a rapid darkening within 48 hours of eclosion. Full eclosion is also very rapid, the adult requiring only about four minutes to fully expand the wings (Fig. 8).

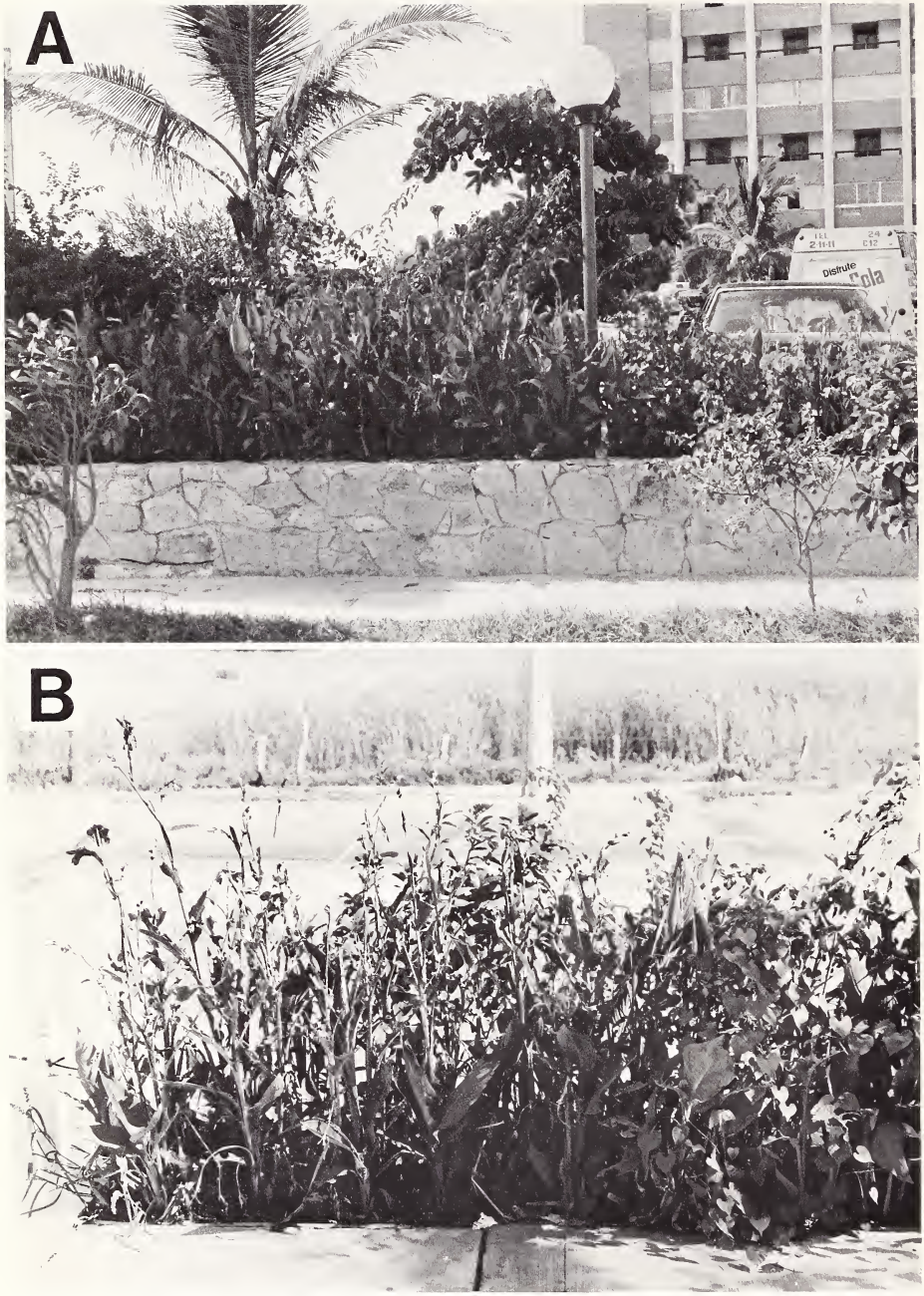


Fig. 5. (A–B) Two other patches of cannas in Mazatlan examined for *C. ethlius*. Note the considerable "thinning out" of leaves from larval feeding (B).

Fig. 6. (A–B) In addition to large patches of cannas, there were also two small patches studied. Both large and small patches exhibited signs of considerable defoliation by *C. ethlius* larvae.

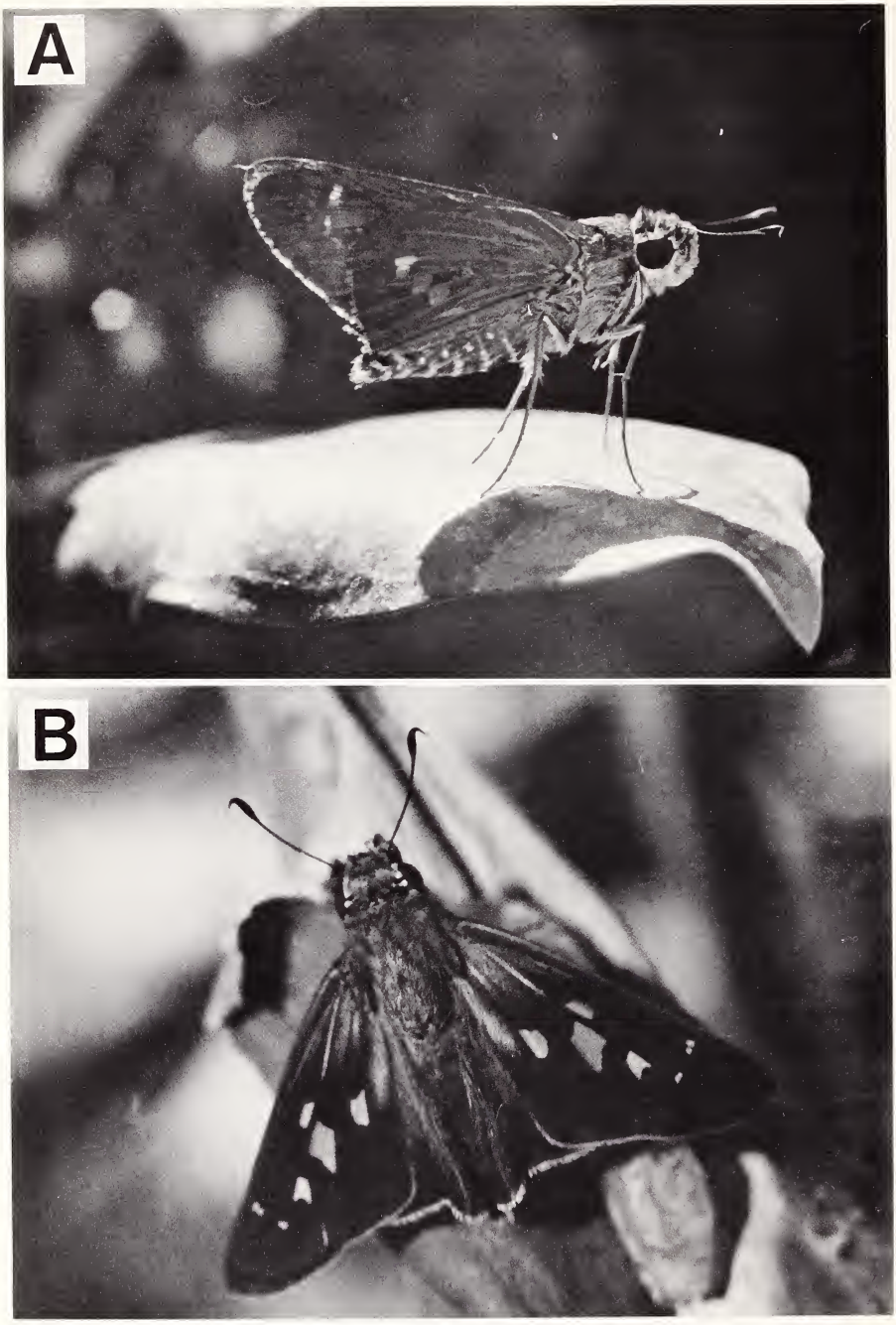
Discussion

Peaks in adult populations of *C. ethlius* in the Mazatlan area, and perhaps in other very seasonal tropical and subtropical regions, are predicted to be synchronized with the growing (wet) season, based upon the age-structure of the population studied here. The low abundance of larvae, pupae, and adults indicates that the population was beyond its period of greatest abundance. My discovery of predominantly old herbivore damage and old fecal pellets indicates further that the period of intense larval abundance had passed. Although the larvae of *C. ethlius* are well known to be occasional severe defoliators of *Canna* (Klots 1951), the impact of the larvae on the host plant population may be a very seasonal occurrence in regions such as Mazatlan. The generation time of *C. ethlius* is probably on the order of 40 days, given the observed duration of the pupa stage and my own experience studying butterfly life cycles in the tropics for the past 11 years. A wet season period of about five months permits three, and possibly four, generations of *C. ethlius*. For many tropical plants, the wet season is the period of maximal vegetative growth (Janzen and Schoener 1968), thus providing an expanded resource base for many herbivorous insects inhabiting seasonal

Fig. 7. (A) Generally more than 90% of the leaves within a single patch of cannas were heavily defoliated by *C. ethlius*; the contrast between a few surviving intact leaves and defoliated leaves is shown here. (B) Very few plants possessed the very conspicuous red flowers even though blooming is generally high early in the dry season. (C) Generally between 20–90% of the leaf surface area were devoured by *C. ethlius* larvae in each patch of cannas studied. (D) *In situ* tent-like structure housing a *C. ethlius* larva; the larva feeds on the same leaf.

environments (Wolda 1978). Under such conditions, there will be strong selection for synchronization of maximal breeding with the wet season in herbivorous insects such as *C. ethlius*. Yet the presence of the tail-end of the immature population during the very early dry season at Mazatlan indicates that such synchronization is somewhat variable, with some overlap between the seasons. The tent-building behavior of the larvae of *C. ethlius* may be adaptive in permitting completion of a generation in the early phase of the dry season in that the shelter, and after-dusk feeding, reduce the chances of larval death from severe desiccation in the open exposed habitats of this region. Such behavior may also preadapt this species to occupy new environments otherwise impenetrable owing to dry conditions, thus contributing to the widespread geographical distribution of the butterfly. Clearly more extensive and long-term field studies are needed to confirm these ideas on the survival of *C. ethlius* in very seasonal environments. As a basis for such studies, a preliminary prediction from my observations in Mazatlan in the early dry season would be that *C. ethlius* attains peak abundance and reproductive activity in the latter half of the wet season, and the population experiences a drastic decline by the beginning of the dry season. Severe herbivore damage of *Canna* patches also occurs in the latter half of the wet season. The age-structure of the *C. ethlius* population during this period consists primarily of adults and larvae, particularly the first three instars. Larvae of two or more generations are abundant at this time. By the beginning of the dry season, the age-structure shifts to a reduced number of adults and very few larvae if any at all. Whether or not adult *C. ethlius* breeds during the long dry season of this region or enters into a reproductive diapause is not known at this time. The observed age-structure of the population at the beginning of the dry season suggests a very depressed abundance of adults at this time.

Calpodes ethlius probably has its greatest impact on the *Canna edulis* population during the latter half of the wet season, a time in which the larval population is peaking in abundance. A good example of this impact is seen in the fact that virtually all plants in the eight patches studied were severely defoliated by *C. ethlius*. Very little new growth was present and the plants were entering into a period of synchronized flowering and fruiting. I learned from two different gardeners familiar with some of the patches studied that (1) flowers are most abundant near the end of the wet season, and fruits during the first half of the dry season, and (2) these patches show signs of severe defoliation each year. The observed high incidence of parasitized pupae suggests that most larvae, even those parasitized, complete the larval stage and pupate, and such mortality therefore does little to regulate herbivore pressure on the host plant. It does, however, reduce recruitment of


A
B

new adults. Whether or not earlier generations in the wet season experience intense parasitism needs to be studied.

The point at which larvae are parasitized is another unknown factor is this system. It is clear, however, that the last major wave of pupae in the population were heavily parasitized and resulted in very low recruitment of new adults. Therefore, it is most likely that seasonality molds the population dynamics of this butterfly. The advancing wet season results in a build up of the population and a gradual depletion of food supply so that when the dry season arrives, food supply is even further reduced by lack of new growth and the breeding population declines. The availability during the late wet season or early dry season of a reduced larval population consisting of later instars, provides a suitable resource base for a hymenopterous parasite which in turn reduces the adult population even further. The early dry season may also be a period very favorable for the parasites thus increasing their impact as a regulatory factor on the *C. ethlius* population. Many parasites are generalists on several species of Lepidoptera in a region, and as some of these host species "drop out" of the herbivore community as the wet season closes, such generalists concentrate on the few remaining species.

Given the size and pattern of emergence holes of the parasites seen on the *C. ethlius* pupae, the suspected parasite is a chalcid wasp, and perhaps a species of *Spilochalcis*. The exit holes and their distribution on pupae resembles very closely *Spilochalcis* parasitism of *Opsiphanes tamarindi sikyon* Fruhstorfer in Costa Rica (Young and Muyshondt 1975). Cockerell (1892) reported high incidence of egg parasitism of *C. ethlius* by another hymenopterous parasite, *Trichogramma* sp., and suggested that such mortality regulates the abundance of this butterfly in Jamaica. With the exception of this observation and that presented here, little is known about the parasites of *C. ethlius*. Whether or not the population in Mazatlan experienced egg parasitism is not known, although perhaps not since larvae were very abundant in at least the late wet season as indicated by the abundance of pupae at that time.

When large larval populations build up on *Canna* patches, they will have a severe defoliating effect, perhaps to the point of reducing leaf surface area to the point where differentiation of flowers and fruit is impaired. Very few

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Fig. 8. (A) *Calpodes ethlius* perched on the leaf of an ornamental plant in a garden in Mazatlan (13 November 1979, 1100 hours). The butterfly is set for flying off as the species exhibits considerable home-range movements involving sudden darting flights and perching periods. (B) A fresh *C. ethlius* within five minutes after eclosion (in Milwaukee, 24 November 1979, 1500 hours).

flowers and fruit were present in all eight patches studied and this scarcity of reproductive structures on mature plants could have been due to the interplay of severe herbivore pressure from *C. ethlius,* and the synchronization of flowering with another time of the year. These observations suggest that herbivore damage by *C. ethlius* reduces the abundance of flowers and fruits in infested patches of *Canna* in Mazatlan. The interaction between *Canna edulis* and *C. ethlius* is intensified further by the observation that this butterfly is a specialized herbivore of Cannaceae, and primarily *Canna* (Scudder 1892; Seitz 1924; Klots 1951; Tietz 1972; MacNeill in Howe (1975) although the Cannaceae share a very close phylogenetic history with the bananas (Musaceae), gingers (Zingiberaceae) and arrowroots (Marantaceae) (Heywood 1978), checking members (ornamental species) of these groups in Mazatlan revealed no larvae or pupae of *C. ethlius,* nor any signs of extensive herbivore damage indicative of larval *C. ethlius.*

Based upon the above considerations, I suggest that Klots's original remark (Klots 1951) about *C. ethlius* larvae that "sometimes they are abundant enough to be destructive" be expanded to consider the interplay of seasonality of climate, vegetative growth patterns of the host plants, and impact of parasites. Another factor to be considered in long-term studies of this interaction relates to the status of *Canna* species as ornamentals. A major portion of the geographical distribution of *Canna* species results from these plants being used as ornamentals in regions where wild species do not occur. Apparently the group had its origin in Central America (Heywood 1978) thriving primarily in moist or wet forest areas. The expansion of these plants as ornamentals into drier regions such as the Mazatlan area provides an evolutionary opportunity for the herbivores normally associated with wild populations to "track the environment" and penetrate new regions where the plants have been introduced. Whether or not under such conditions *C. ethlius* leaves behind its natural regulatory agents (predators and/or parasites) associated with it on wild host plants needs to be determined. Sometimes when a herbivorous insect enters into a new adaptive zone (host plant) it leaves behind its natural enemies (Janzen 1973). If wild host plants are scarce or absent from the region where the ornamentals are being introduced, *C. ethlius* as a colonizing species will concentrate on infesting patches of the ornamentals. It would not be surprising to discover that virtually all patches of *Canna edulis* in the Mazatlan area are severely damaged each year from such an effect. Given the climatic regime of this area, it is unlikely that wild patches of host plant exist, and the known distribution of this butterfly through Baja California and mainland Mexico (MacNeill 1975) is probably largely determined by the presence of ornamental cannas. Being a very strong flier and having the habit of depositing eggs singly on the host plant contribute to *C. ethlius* successfully dispersing itself among

patches of cannas. Depending chiefly upon (1) the intensity of seasonal conditions affecting phenological patterns of vegetative and reproductive growth of the host plants at a locality, (2) the relative abundance of wild and ornamental host plant patches, and (3) the kinds of predators and parasites present, *C. ethlius* adult populations will vary in size at different times of the year. Thus population structure and dynamics of *C. ethlius* will vary considerably both spatially and temporally, to varying degrees. The impact of this insect as a specialized herbivore on cannas is also expected to vary considerably, even to the extent that under some conditions it is one of the determinants influencing the spread of the host plant once the latter is established as an ornamental in a new area.

Acknowledgments

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BOOK REVIEW

Butterflies of the Rocky Mountain States. Clifford D. Ferris and F. Martin Brown, eds. U. Oklahoma Press. 442 p. 4 color plates. 1981. $35 hardbound; $15.95 softbound.

This book is a comprehensive and updated field guide that will be most welcomed by butterfly collectors who could no longer obtain the out-of-print *Colorado Butterflies* by Brown, Eff, and Roger (1957). The prefactory chapters describe the biogeography and geology of the region from the Canadian border to northern New Mexico, as well as some butterflies from the Black Hills and the Pine Ridge Escarpment of South Dakota and Nebraska. All of the species and most of the butterfly subspecies of North America in the four major families, Hesperioidea, Papilionoidea, Lycaenoidea, and Nymphaloidea are illustrated by black-and-white photographs and many are shown in the 4 color plates. Life histories, flight periods, habitats, as well as common names are included. There is a complete glossary of terms, a general bibliography, and distribution maps. The excellent illustrations and well-organized text add to the usefulness of this book. This very reasonably priced field guide will serve not only the serious collector, but also a wide audience, including weekend naturalists and young butterfly collectors.

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